UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

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MEMORANDUM

SUBJECT: Plum/Prune Initial Benefits Assessment for Azinphos-methyl and Phosmet

FROM: Donald W. Atwood, Entomologist
Herbicide and Insecticide Branch
Biological and Economic Analysis Division (7503C)

Jihad Alsadek, Economist
Economic Analysis Branch
Biological and Economic Analysis Division (7503C)

THROUGH: David Brassard, Senior Entomologist
Jonathan Becker, Acting Chief
Herbicide and Insecticide Branch
Biological and Economic Analysis Division (7503C)

Arthur Grube, Senior Economist
David Widawsky, Acting Chief
Economic Analysis Branch
Biological and Economic Analysis Division (7503C)

TO: Diane Isbell, Chemical Review Manager
Veronique LaCapra, Chemical Review Manager
Margaret Rice, Chief
Reregistration Branch 2
Special Review and Registration Division (7508C)

SUMMARY

Azinphos-methyl is used to control a number of plum pests in the Western region including citrus cutworm, codling moth, fruittree leafroller, obliquebanded leafroller, orange tortrix, peach twig borer, and oriental fruit moth. In the Eastern region it is used to control the plum curculio and apple maggot.

Phosmet is used to control many of the same pests. In the Western region, phosmet is used to control citrus cutworm, codling moth, peach twig borer, and oriental fruit moth. In the Eastern region it is used to control the plum curculio and apple maggot.

Extending the REIs of both of these chemical will have the greatest impact on IPM and mating disruption programs. Extension of REIs may cause growers to spray earlier and often times unnecessarily as a prophylactic in order to enter the harvest period without the worry of a damaging pest incursion.

BACKGROUND

Plums are the most taxonomically diverse of the stone fruits, and are adapted to a broad range of climatic and edaphic factors. They are placed within the *Prunoideae* subfamily of the *Rosaceae*, in the subgenus *Prunophora*. There are two main sections within the *Prunophora* which contain cultivated plums: Section *Euprunus* ("true plums") and Section *Prunocerasus* ("plum-cherries" or Native American plums). The main cultivars in U.S. plum production are the European plums (*Prunus domestica* L.) and Japanese plums (*Prunus salicina* L. and hybrids). Prunes are only made from sufficiently firm plums that are sweet enough to dry without fermenting.

Plums are small to medium sized trees, and more erect growing than peaches. The leaves are ovate or elliptic with acute or obtuse tips and short petioles. The flowers are similar in morphology to peach, but white, smaller, and have longer pedicels. Flowers are borne mostly in umbel-like clusters of 2-3 individuals on short spurs, and solitary or 2-3 in axils of 1-yr-old wood. About 50% of Japanese plums and European plums require pollinizers for commercial production. Honey bees are the major pollinator.

The fruit of the plum is oval-shaped or round in European types and round to conical or heart-shaped in Japanese types. Fruit size is generally larger in Japanese types, although this is heavily dependent on thinning. Native American types and their hybrids with Japanese plum often have small fruit size.

Deep, fine-sandy loam soils with good internal drainage and freedom from alkali or salinity are best for optimum plum growth and production. Plum trees will not produce commercially acceptable crops under arid California conditions without supplemental irrigation water. Many plum orchards are furrow or flood-irrigated. No-till cultivation is widely used in California in mature plum orchards. This entails an herbicide-treated berm in the tree row with weeds in the row middles being controlled by mowing.

Plum trees may flower in the second year on laterals, but substantial bearing does not begin until 4 years. Fruit is borne on short spurs, or axillary on 1-yr-old wood. European plums are less precocious than Japanese types, with little spur and fruit production until year 3-4. Fruit thinning is necessary for proper size development for Japanese plum hybrids which can produce tens of thousands of flowers per tree, appearing almost snow-covered. Of this, only 1% should set for a properly sized crop. Fruits are thinned leaving 1-2 per spur or about 1 fruit per 5-6 inches of shoot length; on laterals, 1 fruit is left per 3-4 inches of shoot length. Thinning is done by hand at pit hardening, or with poles or shakers; chemical thinning of blossoms with materials such as DNOC is possible but risky, due to frost threat. However, in California, fruit thinning is an annual practice and hand labor is preferred over mechanical or chemical options. Thinning is not always necessary for prunes. Plums follow a similar pattern to freestone peaches with a harvest season extending from mid May through early October.

The largest production area in the U.S. for plums is California. Approximately 92% of the 1999 U.S. plum production is in CA with bearing acreage of 44,500 acres. In addition, California is the largest prune production region with 1999 bearing acreage of 98,000 acres. Oregon is the second largest U.S. producer of plums and prunes with 1,963 bearing acres. Other production states include Washington, Idaho, and Michigan with less than 6% of total U.S. plum and prune production. However, according to pest complexes being controlled, the U.S. can be divided into a Western region (CA, WA, ID, and OR) and an Eastern region (MI).

California produces 100% of the U.S. fresh market plums/prunes. Total plum production for CA in 1999 was 196,000, all of which was utilized. Prune production in CA for 1999 was 178,000 tons, of which 173,000 tons were utilized. Approximately 50% of plum production in WA, ID and MI were for the processed market. Growers in Eastern Oregon sell the prunes fresh in eastern markets; those in Western Oregon sell their crops dried or canned. Total crop value for U.S. plum and prunes in 1998 was $185,787,000.

USE OF AZINPHOS-METHYL AND PHOSMET ON PLUM/PRUNES

Azinphos-methyl:

Western region - Azinphos-methyl was applied to 734.7 acres of plums and 849.2 acres of prunes in California during 1999.

Eastern region - Use and usage data are not available for the eastern region.

Use in the Western Region:

Target Pests for Azinphos-methyl:

Pests of plum in the Western region, which are controlled using azinphos-methyl, include citrus cutworm, codling moth, fruittree leafroller, obliquebanded leafroller, orange tortrix, peach twig borer, and oriental fruit moth (Crop Profile for Plums in California 1999, Crop Profile for Plums & Prunes in Oregon 2001, Pests of Plums 1998-UC Pest Management Guidelines, Prune and Plum 2001-UC Pest Management Guidelines Pest Management Guide for the Willamette Valley-Oregon State University).

Citrus cutworm - Citrus cutworm is primarily a pest of plums in the San Joaquin Valley, but even there it is not a pest in all orchards or every year. Citrus cutworm has only one generation per year. The grayish citrus cutworm moths emerge from early January to the end of April, with peak emergence during March. Orchards are monitored weekly from early to mid-April through post petal fall to determine if citrus cutworm is a problem. The most critical period is late bloom to post petal fall when cutworm larvae are attracted to the small developing fruit. Citrus cutworm move around while feeding, usually taking a few bites from numerous leaves, blossoms, or fruit. Young larvae feed mostly on the edges of tender leaves; older larvae eat holes through leaves and blossoms and into fruit. A smaller number of citrus cutworms cause more damage than larger numbers of other caterpillars because they are larger and move throughout the tree during feeding. Mature fruit are rarely attacked.

Codling moth - After overwintering as mature larvae in silken cells under loose bark on the tree, moths emerge from March to May. Adults mate and lay eggs; larvae feed on small fruit. A second generation appears in June and often a third one in August, depending on temperatures. Fruit feeding by the codling moth has resulted in a high percentage of unmarketable fruit in some San Joaquin Valley orchards. Codling moth larvae usually tunnel all the way to the pits of fruit; extrusions of frass or excrement are often found at the entrance of the larval tunnels.

Fruittree leafroller - During bloom, larvae feed on leaves and buds. Later in the season they can feed on the surface of fruit, causing severe damage. Fruit often becomes infected with brown rot at feeding wounds. Dormant to delayed dormant oil sprays help suppress overwintered populations of this pest. You can also treat effectively for leafroller during the green bud stage. Later treatments, such as a petal fall spray for thrips, will also control this pest. After petal fall, monitor this pest by looking for rolled leaves or leaves tied to fruit. If no insects are present in rolled leaves, do not treat. Using *Bacillus thuringiensis* at bloom to control peach twig borer will also control fruittree leafrollers.

Obliquebanded leafroller - Oblique-banded leafroller overwinters as larvae in the bud scales of twigs; there are two to three generations each year. On plums, larvae feed on leaves and buds during bloom and also on the surface of fruit in midsummer. In some cases they cause severe damage as well as contamination with their excrement. Insecticide sprays are timed to kill caterpillars when they occur in damaging numbers.

Omnivorous leafroller - Omnivorous leafroller is a pest of plums, primarily in the San Joaquin Valley. It occurs in the Sacramento Valley, but seldom causes damage. Omnivorous leafrollers overwinter as immature larvae in mummy fruit and do not enter dormancy. Omnivorous leafroller larvae often web leaves into rolled, protective shelters while feeding. They feed on leaves and on the surface of fruit, sometimes webbing one or more leaves to the fruit for protection. They chew shallow holes or grooves in the fruit surface, often near the stem end. Primary damage results from fruit feeding. Young fruit may be destroyed, and scars on older fruit will cause them to be culled or downgraded at harvest. Feeding injury also may increase the incidence of brown rot and other fruit decays.

Orange tortrix - The orange tortrix overwinters as larvae and there are two to four generations each year in coastal areas. Larvae feed on leaves, buds, and the surface of fruit, causing severe damage, as well as contamination with their excrement. Fruit is sampled weekly to monitor damage beginning in June to determine spray timing. Twenty fruit are sampled on 15 trees for a total of 300 fruit. Treatments are warranted if between 1 and 2% damage occurs on fresh market fruit.

Peach twig borer - Peach twig borer can damage stone fruits by feeding in shoots and causing shoot strikes, or by feeding directly on the fruit. Shoot damage is most severe on the vigorous growth of young (first to third leaf), developing trees because feeding kills the terminal growth and can result in undesirable lateral branching. As fruit matures, it becomes highly susceptible to attack; damage is most likely to occur from color break to harvest. Twig borer larvae generally enter fruit at the stem end or along the suture and feed just under the skin.

Oriental fruit moth - Oriental fruit moth cause damage by feeding on developing shoots and fruit. They overwinter as mature, diapausing larvae inside tightly woven cocoons in protected places on the tree or in the slash and debris near the base of the tree. In early spring, pupation takes place inside the cocoon and adults begin emerging in February or early March. Eggs are deposited on newly emerged shoots and the larvae feed in terminals where they complete their development. Feeding on the shoots causes the tip of the shoot to die, causing shoot strikes or flagging. The most severe damage occurs where larvae feed on fruit, causing it to be rated off grade. Larvae bore to the center of the fruit and feed around the pit. Feeding damage may also increase the incidence of fruit decay. After reaching maturity, the larvae exit from the fruit and pupate. There are generally five generations per year in California, though a sixth generation has been observed in years with warm weather in early spring.

In orchards treated with insecticides, shoot strikes is monitored early in the season, especially in April and early May, to assess the development of a potentially damaging problem. If the number of shoot strikes is excessive, insecticides are applied to the second flight in order to reduce oriental fruit moth population levels. In orchards with heavy infestations, additional sprays are needed to prevent fruit damage at harvest.

Fruit is also monitored for the presence of worms. Generally fruit is most heavily attacked in the tops of the trees, so fruit samples should be picked and examined from that area. Although green fruit can be attacked, fruit is most susceptible to attack by oriental fruit moth after color break.

Either bait pans or pheromone traps are used to monitor adult flights. Once the first moth is trapped, degree-days (DD) are accumulated to estimate when the onset of the second flight will occur, usually in May. Once the second flight has started, treatments are applied at 500 to 600 DD to achieve optimum control. Moths are continuously monitored until the crop is harvested in order to detect late-season peaks or migrations of moths from adjacent orchards. If treatments are

needed for the third and fourth flights, sprays are made at 400 DD after the start of the flight if the fruit is coloring; or 500 DD if it is not coloring.

Alternative Pest Control Methods:

Citrus cutworm- *Bacillus thuringiensis* and carbaryl are the only non-OP alternative insecticides recommended to control citrus cutworm. Use of carbaryl has decreased because of potential resistance and it generally causes spider mite outbreaks. Diazinon and phosmet are also considered an alternative to control this pest. Diazinon may induce other pest problems and has been documented as causing resistance in San Jose scale.

Codling moth - Carbaryl, permethrin, esfenvalerate, and *Bacillus thuringiensis* are the non-OP alternatives suggested for control of codling moth. However, carbaryl may cause increased spider mite problems and is not recommended for routine use, especially early in the season. *Bacillus thuringiensis* can be effective but timing is critical to ensure small larvae due to the short residual period. In addition, *Bacillus thuringiensis* coverage must be complete and control may require multiple applications. Permethrin has the potential to create secondary pest problems. Phosmet and methidathion are the recommended alternative OP's to control codling moth. However, although methidathion has been widely used, usage will probably decrease due to potential signs of resistance in San Jose scale.

Fruittree, Oblique-banded, and Omnivorous leafroller - Dormant to delayed dormant oil sprays help suppress overwintered populations of this pest. Dormant oils may be used in conjunction with diazinon, chlorpyrifos, or esfenvalerate. However, inclusion of diazinon and chlorpyrifos has the potential for surface runoff, and chlorpyrifos is only available for use under a SLN label. Esfenvalerate is persistent and residues may increase potential for spider mite infestations.

Fruittree leafroller may be controlled during the bloom period using *Bacillus thuringiensis*. Application timing is critical when larvae are small. Application of *Bacillus thuringiensis* should be made prior to bloom followed by a second application 7-10 days later.

Insecticides registered for fruitree leafroller control post-bloom include: diazinon, chlorpyrifos, spinosad, carbaryl, and *Bacillus thuringiensis*. Resistance may occur when successive applications are made using the same product. Carbaryl may also cause an increase in spider mite populations and is not recommended for routine use and particularly early season use. *Bacillus thuringiensis* can be effective but timing is critical to ensure small larvae due to the short residual period. In addition, *Bacillus thuringiensis* coverage must be complete and control may require multiple applications. Chlorpyrifos is the most effective material for control of leafrollers post-bloom.

Orange tortrix - Three alternative insecticides are recommended to control orange tortrix. These are diazinon, carbaryl, and *Bacillus thuringiensis*. Carbaryl may cause spider mite problems and is not recommended for routine use, particularly early season. Timing and coverage is essential for control using *Bacillus thuringiensis*. In addition, control using *Bacillus thuringiensis* may require multiple applications.

Peach twig borer - Dormant to delayed dormant oil sprays help suppress overwintered populations of this pest. Dormant oils may be used in conjunction with diazinon, chlorpyrifos, or esfenvalerate. However, inclusion of diazinon and chlorpyrifos has the potential for surface runoff, and chlorpyrifos is only available for use under a SLN label. Esfenvalerate is persistent and

residues may increase potential for spider mite infestations. Spinosad and methidathion are also registered for pre-bloom control of the peach twig borer.

Peach twig borer may be controlled during the bloom period using *Bacillus thuringiensis* or mating disruption. Application timing of *Bacillus thuringiensis* is critical when larvae are small. Application of *Bacillus thuringiensis* should be made prior to bloom followed by a second application 7-10 days later.

Insecticides registered for peach twig borer control post-bloom include: diazinon, spinosad, esfenvalerate, carbaryl, endosulfan, and phosmet. Use of high rates of esfenvalerate is not recommended as it will cause severe outbreaks of secondary pests. Low rates of esfenvalerate should only be used where OP resistance has occurred and where mating disruption is not feasible. Diazinon may induce other pest problems. Carbaryl is not recommended but is the only chemical the can be used under certain emergency conditions because of its 1 day PHI.

Oriental fruit moth - Oriental fruit moth control can be achieved with mating disruptants (pheromone) or insecticides. Alternative insecticides to control this pest include methomyl, esfenvalerate, diazinon, and carbaryl. However each of the alternatives has resistance problems or can be disruptive of established IPM programs. Resistance to diazinon is suspected but has not been documented. Methomyl is not compatible with IPM programs and is no longer used as a clean-up material due to the increase in REI to 4 days. Carbaryl is not recommended but is the only chemical the can be used under certain emergency conditions because of its 1 day PHI.

Mating disruption can be effective to control Oriental fruit moth. However, this is the least popular control method mainly due to costs. Mating disruptants are applied just before or at first moth emergence in spring (roughly around March 1). Replace baits on product recommendation, usually 3 months. Two current products are Isomate M-100, applied at a rate of 150 dispensers per acre, and Checkmate SF Dual OFM + PTB, applied at 150 dispensers per acre. These are applied by hand labor. Growers and PCAs are reluctant to use pheromone mating disruption due to the potential for secondary pest outbreaks of oblique-banded leafroller (OBLR) and katydids, the increased cost of pheromone application and the difficulties some growers have experienced with mating disruption failure to suppress reproduction of the target pest. Azinphos-methyl and phosmet are still essential when recovery applications are necessary due to failure of mating disruption programs.

Use in the Eastern Region:

Target Pests for Azinphos-methyl:

Target pest for control using azinphos-methyl in the eastern region include plum curculio and apple maggot.

Plum curclio - The plum curculio is one of the most important insects attacking tree fruits. It is particularly destructive, and the problem is intensified where stone fruits and apples are inter-planted. The insect overwinters as an adult under debris in and around the yard or in protected places at an orchard. In spring, shortly after peaches bloom or when apples are near the pink stage, the beetles come out of hibernation and begin to fly to fruit trees to feed.

Both the adult and larval stages injure fruits. In spring, adults feed on buds, blossoms, leaves, and new fruits. Overwintering adult beetles attack the fruit soon after it forms and eat holes through the skin and feed on the pulp, usually next to the pit.

The major injury occurs from the laying of eggs by the curculios (weevils). A small cavity is made in the fruit for the egg; then a crescent-shaped cut is made adjacent to the egg pocket. Each female is capable of laying from 100 to 500 eggs with an incubation period of about one week. Larvae hatching from the eggs feed inside the fruit until they are fully grown. On some fruits, few if any of the young larvae survive to maturity if the fruits continue to grow on the tree. The mechanical injury by adults in feeding and egg deposition can cause premature fruit drop.

Apple maggot - The apple maggot passes the winter in the pupal stage in the top 2 or 3 inches of soil. In the summer, these pupae give rise to flies, which emerge from the soil from late June through early September. The flies do not begin to lay eggs until eight to 10 days after emergence. During this period, called the preoviposition period, both the males and the females rest and feed in the general area in which they emerge. They move readily from tree to tree but normally only for short distances, usually no more than 200 or 300 yards.

Female apple maggot flies deposit eggs singly just below the skin of an apple or other host fruit. When the female lays an egg, a small but visible puncture is made in the fruit which can lead to "dimpling." Eggs are elongate (l/16 inch)* curved, smooth, and white. Depending on temperatures, the eggs hatch after a 3-7 day incubation period. The tiny cream-colored larvae (maggots) feed in the fruit, passing through three growth stages. The damage caused by the maggot resembles a series of brownish, irregular tunnels called railroading. The tunnels are enlarged by bacterial decay that often follows apple maggot damage. Damaged fruit eventually becomes soft and rotten and cannot be used. There is one generation per year.

Alternative Pest Control Methods:

Plum curclio - Recommended alternatives to control plum curculio in the Eastern region are phosmet and esfenvalerate.

Apple maggot - Phosmet is the only alternative to azinphos-methyl for control of Apple maggot in the Eastern region.

Phosmet:

Western region - Phosmet is applied to 16.0% of CA plum. Phosmet use in CA on plums/prunes is 4.3% of total phosmet agricultural use in the state. Phosmet was applied to 9,504.9 acres of plums and 1,231.4 acres of prunes during 1999. Plums were treated on average 1.7 times at a rate of 2.9 lbs ai/acre/application (1.5-3.0 lb ai/acre labeled rate). No phosmet use was reported on prunes in CA during 1999.

Eastern region - Use and usage data are not available for the eastern region.

Use in the Western Region:

Target Pests for Phosmet: Pests of plum in the Western region that are controlled using phosmet include citrus cutworm, codling moth, peach twig borer, and oriental fruit moth.

Citrus cutworm - See azinphos-methyl.

Codling moth - See azinphos-methyl.

Peach twig borer - See azinphos-methyl.

Oriental fruit moth - See azinphos-methyl.

Alternative Pest Control Methods:

Citrus cutworm - See azinphos-methyl.

Codling moth - See azinphos-methyl.

Peach twig borer - See azinphos-methyl.

Oriental fruit moth - See azinphos-methyl.

Use in the Eastern Region:

Target Pests for Phosmet:
Target pest for control using phosmet in the Eastern region include plum curculio and apple maggot.

Plum curclio - See azinphos-methyl.

Apple maggot - See azinphos-methyl.

Alternative Pest Control Methods:

Plum curclio - Recommended alternatives to control plum curculio in the Eastern region are esfenvalerate and azinphos-methyl.

Apple maggot - Azinphos-methyl is the only recommended alternative to phosmet for control of apple maggot in the Eastern region.

Restricted Entry Intervals

Azinphos-methyl:

Current label REI's	REI= 14 days hand harvest / hand thin, 2 days for all other activities (3 days if rainfall less than 25 inches)
PHI	15 days

Phosmet:

Current label REI's	24 hours for all activities 5 day for all activities in CA
Registrant proposed REI's	A 14 day REI with an early entry exception of 3 days for hand thinning
PHI	7 days

Please refer to the occupational and residential human health risk assessment on the Agency's website (http://www.epa.gov/pesticides/op) for information concerning the worker risks associated with the restricted entry intervals for this chemical.

IMPACTS ON CROP PRODUCTION*:*

Fruit Thinning – Plum trees produce more fruit than can mature to a commercially competitive size on the fresh market. Consequently, fruit must be thinned, whereby excess plums are selectively removed, primarily by-hand, and on occasion with rubber hoses by tapping the fruit to dislodge them.
Thinning usually begins April 1st and is usually completed by the middle of May but occasionally orchards may have to be re-thinned when to much fruit was mistakenly left the first time or when hail damage occurs. On average it takes 103 hours per acre to thin a plum orchard at a labor cost of $828 for July/August harvested varieties. Timely thinning is crucial to the production of fresh market fruit with acceptable fruit size.

In contrast to plum production, prunes are generally thinned by mechanical shaking. Prune thinning may be either through contract or rental of shaking equipment. Cost to thin prune acreage, custom/rental, is approximately $73 per acre.

Phosmet spraying to reduce second generation pest numbers, concurrent with a mating disruption program, occurs in June and July. When considering this time frame, the proposed REI for plum thinning would only have an impact in orchards that might require a second thinning as described above. Similarly, the first azinphos-methyl application usually occurs between May 21 - May 28. This again suggests that hand thinning would only be of concern for orchards that must be re-thinned. There would be no impact of extended REIs on fruit thinning for prunes.

Propping - Plum and prune limbs are propped to prevent limb breakage through the growing season as fruit size increases. Props are removed at the end of harvest. Extension of azinphos-methyl and phosmet REIs beyond that currently observed in CA could result in production loss as well as tree damage.

Harvesting - Fresh market plums and prunes are harvested by hand. Fruit that is canned or dried is usually harvested by shakers similar to nut crops. Extending the azinphos-methyl and phosmet REIs for hand harvesting to that equal to the PHI (7 days for phosmet; 15 days for azinphos-methyl) should not result in an grower impact.

IPM Disruption - It is also projected that a phosmet REI of 7 days or greater would result in the use of less desirable replacement insecticides, i.e., synthetic pyrethroids that are less compatible with integrated pest management (IPM); precipitate secondary pests outbreaks such as San Jose scale and spider mites, and cause growers to resort to the use of expensive miticides. Use of the non-OP alternative insecticides would solve the pest problem but would predictably cause a flair up in spider mites within 30-45 days. To avoid catastrophic damage to the orchard resulting from defoliation caused by spider mites, additional pesticide applications would be necessary to control this pest at a cost of $35-80 per acre. In addition, extension of REIs beyond those which have been proposed would mandate prophylactic insecticide application to ensure crop protection prior to harvest.

Mating Disruption Program - As some producers have moved away from OPs to softer insecticides, new primary pests have emerged. Katydids, lygus bug, stink bug, and chinch bugs have regained primary pest status in orchards which have moved to softer insecticide programs based on *Bt* and mating disruption. It generally takes 2 years after a grower ceases using OP materials for the population of these pests to build to dangerous levels.

Many of the new materials are surgical in nature and tend to address only one pest. A mating disruption program in situations where producers have problems with peach twig borer, oriental fruit moth, scale, and oblique-banded leafroller would require the use of 4 different materials and sufficient time to monitor 4 different life cycles. In this situation the farming operation would likely not see a profit. Conversely, if pest

pressures are low and only one or two pests are a threat, mating disruption and application of *Bt's* can make good economic sense. For late season varieties which have a history of problems with oriental fruit moth and peach twig borer, phosmet is usually used only to knock down population in the second flight. However, it is important to have phosmet available in the event of a late season incursion where populations surpass maximum threshold. Extension of REIs may cause growers to spray earlier and often times unnecessarily as a prophylactic in order to enter the harvest period without the worry of a damaging pest incursion.

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